Developing Inclusive and Sustainable Curriculum for Environmental Engineering Courses

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Abstract

Inclusivity and sustainability are becoming integral to the successful delivery of engineering course content. Teaching strategies that incorporate both are gaining momentum globally for engineering educators. Inclusive teaching strategies are based on making all students in the classroom feel valued and equal contributors. Strategies are based on developing curricular material that addresses students from a diverse background (socioeconomic status, race, gender, ethnicity, preferred orientation) and varying learning abilities. Research has shown that inclusive teaching strategies allow instructors to engage and bond with their students and the students bond with the course content. ABET, the accreditation arm for engineering programs has also identified that student outcomes address engineering design that integrates sustainability, ethics and the impact of engineering solutions in a global context. As such engineering educators are challenged to integrate all these concepts in courses that have a finite time for delivery of technical core content.

The Civil and Environmental Engineering department at Rowan University initiated an effort titled "Sustainability Across the Curriculum" in 2008. The department received NSF RED funding in 2017 for a grant titled *"Revolutionizing Engineering Diversity (RevED)"*. The goal of this project is to revolutionize the Civil and Environmental Engineering (CEE) Department by radically increasing diversity and retention of women and Underrepresented Minority (URM) students and historically underserved groups. There are five major objectives of this grant:

1. Revise admissions criteria
2. Provide D&I (Diversity & Inclusivity) training to faculty and administrators
3. ***Integrate D&I concepts in core civil engineering courses***
4. Mentoring programs to help retain students
5. Expose role models from industry/academia

This paper addresses the changes made to Fluid Mechanics, Water Resources Engineering, Sustainable Civil and Environmental Engineering and Environmental Engineering (Water and Wastewater Treatment & Design) courses to integrate inclusive content that also focused on sustainability, global, ethical, social and racial injustices. Each course was assessed at the end of each semester to evaluate the impact of the changes on the course. Our Spring 2019 and Fall 2019 course assessments are extremely promising. Students in focus groups were also included for feedback. The assessment tools indicate that the courses are covering the concepts well.

1 Introduction

1.1 Engineering Curriculum

Diversity and inclusivity (D&I) have gained momentum in engineering education and professional practice [Riley et al., 2006; Riley and Claris, 2006]. The lack of diversity in STEM fields still remains of concern today [Peixoto, A., et al, 2018; Philips, K., 2014]. One key factor that has been identified as the reason for the lack of diversity is that engineering educators use teaching pedagogy that is unappealing to students from various diverse backgrounds. This can lead to a chilly unwelcoming climate in their classrooms. Faculty may be unaware that their teaching content may contribute to the departure of students in STEM fields [Beasley and Fischer, 2012; Farrell and Minerick, 2018; Harriet et al., 2019].

As such many researchers [Delaine et al., 2015; Farrell et al., 2017; Riley and Claris, 2003] have advised engineering educators to revise their teaching pedagogy that is attractive to diverse groups and reflects inclusive practices. Institutions globally are now invested in promoting better dialogues, provide mentoring opportunities and train educators to attract and retain students who not only meet the definitions of URMs (Under Represented Minorities) but also represent other vulnerable/historically underserved groups such as first generation, low socio-economic status and other undisclosed groups.

1.2 NSF RED Grants

The National Science Foundation introduced the RED (Revolutionizing Engineering Departments) program to build upon previous efforts in engineering education research. The NSF RED grants were introduced specifically to revolutionize approaches and strategies for transforming undergraduate engineering education. Strategies and approaches that involved changes in cultural, organizational, structural and pedagogical changes. The first RED awards were made official in 2016.

1.3 Civil and Environmental Engineering Curriculum

The Civil and Environmental Engineering department at Rowan University is the first recipient of an NSF RED award. Our NSF RED grant is titled *"Revolutionizing Engineering Diversity (RevED)"*. The major goal of this project is to revolutionize the Civil and Environmental Engineering (CEE) Department by radically increasing diversity and achieve high retention and graduation rates of all CEE students. A multi-pronged approach has been undertaken to meet this bold goal. The five steps taken to ensure this are:

1. Revise admissions criteria

2. Provide D&I (Diversity & Inclusivity) training to faculty and administrators
3. ***Integrate D&I concepts in core civil engineering courses***
4. Mentoring programs to help retain students
5. Expose role models from industry/academia

Many publications have reported on these multi-step initiatives and their success/challenges in implementation [Hartman et al., 2018; Forin et al., 2018a,b; Ingram et al., 2017; Sukumaran et al., 2017]. As part of the NSF RevED grant, all core civil engineering courses were identified for curricular content reform. Table 1 presents all the courses that were part of this initiative.

Table 1: Civil Engineering Core Course Selected for D&I Content Revision

Sophomore Year (4)	Statics	Solid Mechanics	Civil Engineering Systems	Surveying
Junior Year (10)	Structural Analyses	Analyses & Design of Steel Frames*	**Fluid Mechanics***	**Water Resources Engineering***
	Material Science	Civil Engineering Materials*	Geotechnical Engineering*	Transportation Engineering
	Environmental Engineering*	**Sustainable Civil and Environmental Engineering**		
***courses with lab**		***Courses in bold identified for this paper***		

This paper specifically focuses on four select courses: Fluid Mechanics (2 cr), Water Resources Engineering (3 cr), Environmental Engineering (3 cr) and Sustainable Civil and Environmental Engineering SCEE (3 cr), that were identified and incorporated changes in curricular content to include diverse, inclusive content that also integrated ethics, on sustainability, global, ethical, social and racial injustices. All four courses are required to be taken by students in their junior year.

2 Project Implementation

A number of measures were taken by the department to ensure successful faculty buy-in, content development, implementation of course content and the assessment of the courses. Four steps were taken to ensure the success of course content development and implementation. These are presented in Figure 1.

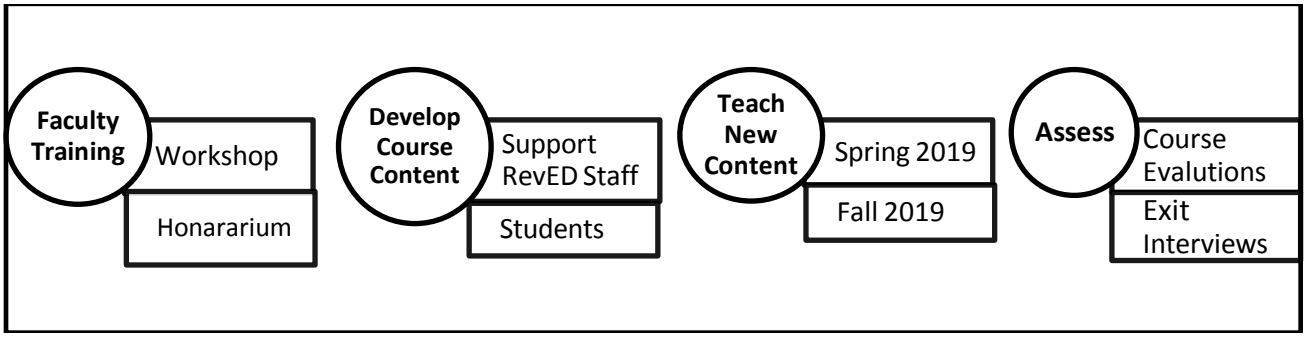


Figure 1: Course Revision Implementation Steps

2.1 Faculty Training and Course Development

An all day workshop was arranged for the faculty to learn the meaning of inclusive curriculum and practice developing inclusive language for their course syllabi, learning objectives, problem wording, assignments and lecture examples. Julia M. Williams and Ella Lee Ingram from Rose-Hulman Institute of Technology conducted this workshop. Faculty were paid a small summer honorarium to invest their time in this endeavour. During the Spring 2018 and Fall 2018 semesters, faculty were also supported by the RevED coordinator and a group of undergraduate students to assist with the development of curricular materials.

2.2 Implementation and Assessment of the Courses

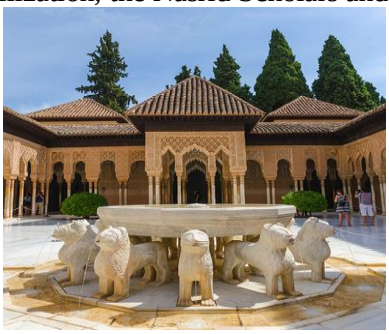
The four courses mentioned earlier, were offered with the new content in the Spring and Fall of 2019. Changes to the course included the following:

- Syllabus Rewording
- Reword technical problem wording
- PowerPoint Presentations on case studies
- Assign a team project (report, presentation, video, brochure)
- Assign team names based on people of influence or the team adopts a country
- Assign teams to watch a movie that focuses on diversity, social injustices, ethic violations, gender biases
- Add questions on quizzes/exams
- Test students in different ways (Take home, Team assignment, Open book)
- Field Trip
- Extra credit- Diversity issues
- Extra Credit- Appreciation for the arts from various cultures

The first four strategies are required for all courses. The four courses identified for this paper used all the strategies identified above. These strategies are described on our RevED website in details for each course [NSF RevED]. Examples for the inclusive course content in the Environmental Engineering and Sustainable Civil and Environmental Engineering, Water Resources engineering courses are presented in Figure 2.

Using a Global example

Ask students in Water Resources Engineering to determine how the waterworks were constructed in the Al-Hambra Palace in Granada Spain. Students learn about the Sierra Nevada Mountains, the Moor civilization, the Nasrid Scholars and their contributions to science and technology.



MOVIES

Assign teams to watch a movie/documentary-not all need to be on a technical contribution.

- Legally Blonde- Good message- you can be blonde, beautiful and like pink and be smart!
- Whale Rider – Society wants women to prove themselves before they can be picked as a leader
- Rosalind Franklin: The Dark Lady of DNA- struggled with lack of confidence-a very human trait in our students
- Stephanie Kwolek – Confident about her knowledge
- Bhopal Express – How India forced Union Carbide to change laws in the USA for People Right to Know !
- Erin Brockovich – Her curiosity and compassion led to justice and the larget class action law suit. Still an activist to this day
- A Civil Action – John Travolta; movie based on real case
- The Imitation Game- Life of Alan Turing

TEAM NAMES

- Assign teams a name of a person of influence or the team adopts a country. Use examples that are global and a learning opportunity for the students. ***Not every person assigned has to be a scientist or engineer. Have the team use the name throughout the semester.*** Present for 2 minutes about the assigned person every other week.

- ***Example- Henrietta Lacks, Ruth Bader Ginsburg, Nelson Mandela, Queen Victoria (major scientific contributions made during her reign), Vandana Shiva, Arundhati Roy, F. R. Khan etc***

Rewording a Problem

- Design a batch reactor with …> *A developing community needs to have access to safe drinking water. A batch reactor will serve their needs.*
- Calculate the alum dose …. > Alum is an universal coagulant and is used extensively in poor and developing communities. Calculate the alum dose ……

Syllabus Wording: Inclusive Learning Environment

It is my intention that students from all backgrounds and perspectives will be well served by this course, and that the diversity that students bring to this class will be viewed as an asset. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability and other visible and nonvisible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class. If you feel that your contribution is not being valued for any reason, please speak with me privately.

Figure 2: Examples of inclusive measures taken for civil engineering courses [Jahan et al., 2018]

The assessment tool used for evaluating the impact of the curricular content change sis presented in Figure 3.

CEE RevED CURRICULUM SURVEY

Question 1: Do you think the course adequately covered the following topics?
(1=Not Covered 5= Adequately Covered)

a) Global Issues
b) Societal Issues
c) Ethical Issues
d) Problem Solving Techniques
e) Engineering Design
f) Diversity & Inclusivity

Question 2: The course
(1= Strongly Agree 5= Strongly Disagree)
A) Included socially relevant examples of engineering work
B) Increased my interdisciplinary knowledge
C) Exposed me to the arts, social sciences and humanities as relevant

Question 3: The course
(1= Strongly Agree 5= Strongly Disagree)
a) Used various types of graded work
b) Used open-ended problems
c) Provided opportunities for collaborative work

Figure 3: Survey Questions for Course Evaluation

3 Results

The results of the survey are presented in Figure 4 a,b and c. For all questions, 75% or more students

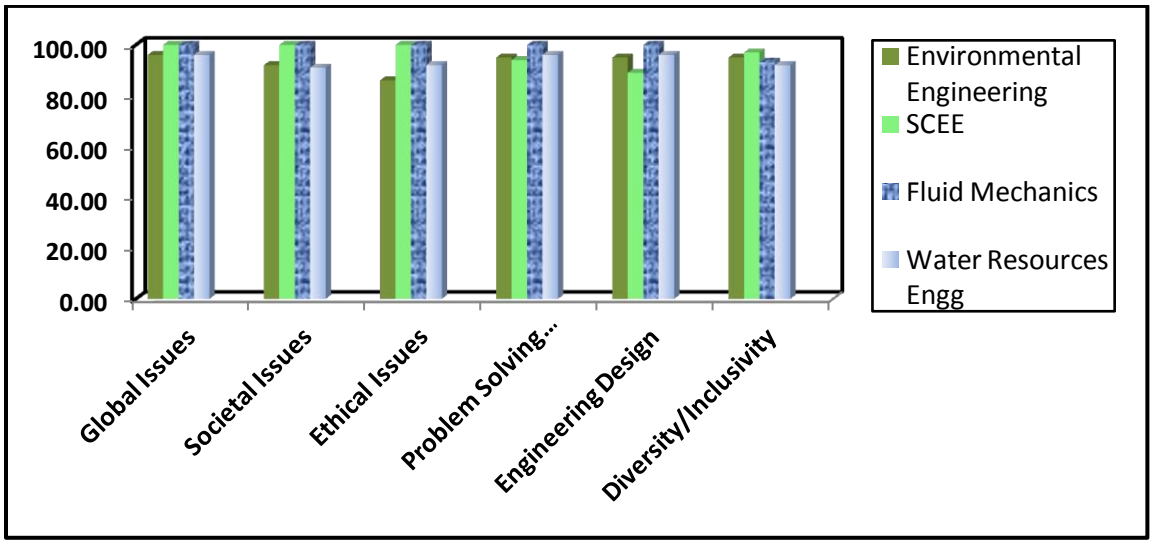


Figure 4 (a): Results for the 4 courses for Question 1

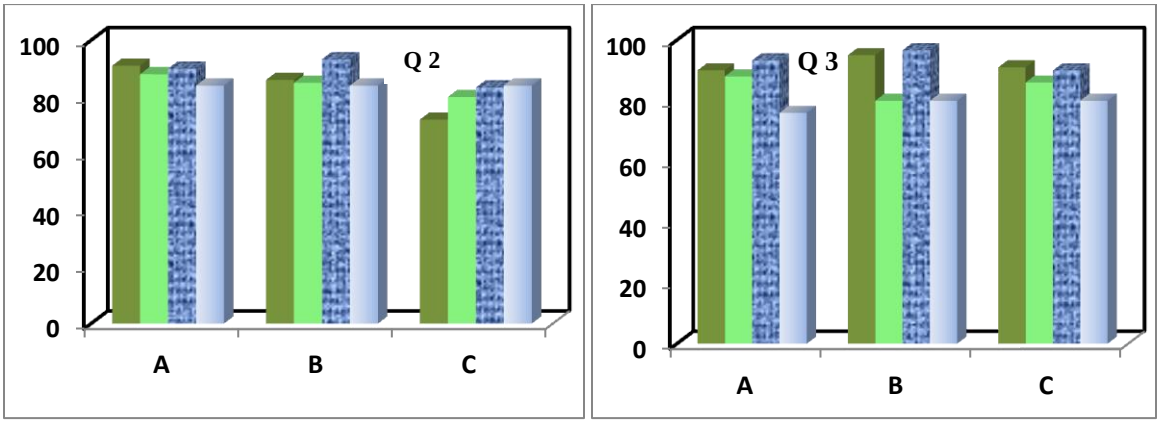


Figure 4 (b,c): Results for the 4 courses for Question 2 and 3

responded favourably to the questions posed about whether the courses were adequately covering concepts that were at the core of the changes in curricular content. These are very encouraging as the courses content were implemented and assessed for the first time. Exit interviews with graduating seniors in Spring 2019 were also positive. All 66 graduating seniors indicated that the courses were interesting, engaging and exposed them to engineering practices that allowed addressing sustainability in a global, social context. The challenges posed are training adjunct and temporary faculty about these changes. Students also complained about survey fatigue as they had to take the same survey for multiple courses.

4 Conclusions

This paper has described how courses in the civil engineering curriculum were revised to integrate inclusive curriculum that also focuses on sustainability, ethics, social, global and racial content. Faculty have to continuously improve their course content and delivery to ensure successful inclusive strategies. While the initial course assessments are very encouraging, challenges will remain in constantly keeping faculty invested in updating the course content.

5 Acknowledgements

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